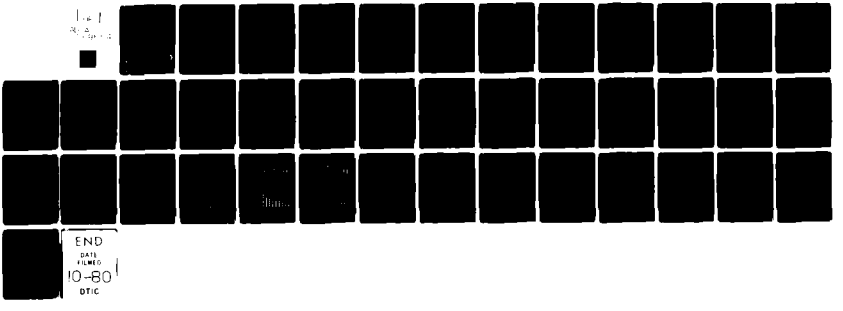
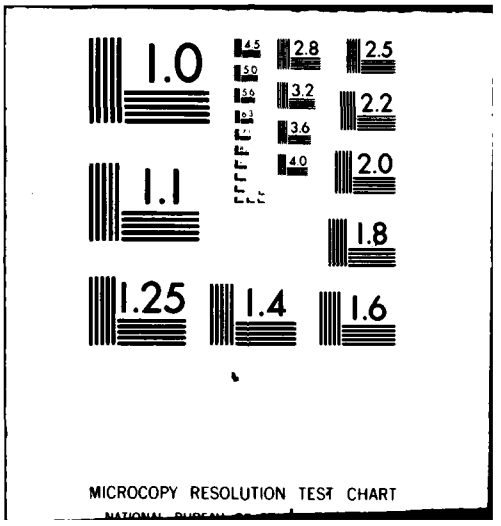
AD-A089 654 AIR FORCE LOGISTICS COMMAND WRIGHT-PATTERSON AFB OH F/G 15/5
EOQ HOLDING COST EVALUATION,(U)
SEP 79 C HAWKS

UNCLASSIFIED NL



END
DATE FILMED
10-80
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART

(6) EOQ HOLDING COST EVALUATION

(9) FINAL REPORT,

(11) SEP [redacted] 79

(12) 41

BY

(10) CAROL HAWKS

CONDUCTED BY

CAROL HAWKS
DEBRA WOODS
HQ AFLC/LORRA

DOD LOGISTICS STUDY SUMMARY

1. LD NO.	2. DATE OF SUMMARY
	08/80

3. TITLE AND ACRONYM

EOQ Holding Cost Evaluation

4. STATUS	5. STARTING DATE	6. COMPLETION DATE	7. ORGANIZATION REPORT NO.
Complete	09/78	08/79	

8. DLSIE SEARCH NO.	9. CONTRACT NO.	10. TYPE STUDY	11. TIME FRAME	12. COST
		In-House	Indefinite	

13. SECURITY CLASS	14. DISTRIBUTION LIMITATION	15. MAN-YEAR EFFORT
None	Unlimited	.3

16. STUDY SPONSOR

HQ AFLC/LORFC
WPAFB OH 45433

RESPONSIBLE INDIVIDUAL Jerome Kaple

AUTOVON 787-3407

COMMERCIAL NO. (513) 257-3407

17. PERFORMING ORGANIZATION

HQ AFLC/LORRA
WPAFB OH 45433

RESPONSIBLE INDIVIDUAL Carol Hawks

AUTOVON 787-3180

COMMERCIAL NO. (513) 257-3180

18. ABSTRACT (UNCLASSIFIED)

SUMMARY

The primary purpose of the holding cost study was to build a reference chart of the effect on purchases and support statistics for use when the holding cost changed. The relationship between holding cost and ordering cost in the EOQ formula allows this chart to also be utilized when the ordering cost changes. A secondary result of the study was charts showing the relationship between holding cost, shortage cost and buy dollars or backorders or fill rates. (cont on atch sheet)

19. CONCLUSIONS (UNCLASSIFIED)

"See Abstract"

20. RECOMMENDATIONS (UNCLASSIFIED)

"See Abstract

21. IMPLEMENTING ACTIONS (UNCLASSIFIED)

EOQ holding cost varies from ALC to ALC. Each year these holding costs are updated and can change. As they change questions arise as to what will happen to buy dollars, fill rates, backorders and number or purchases. This study simulated samples of items through a period of time using several holding costs. Comparison of the resultant buy dollars, fill rates, backorders and number of purchases showed the effect of changing the holding cost. The magnitude of the effect varied depending on the initial holding cost. The tables included show this effect of changing the holding cost through a wide range of feasible holding costs.

The simulation results were also used to develop a graph showing which combination of holding costs and shortage costs should result in the same level of spending. This is helpful when funding is already determined but the holding cost must change and the shortage cost that will allow the funding to remain constant must be determined. Similar graphs were developed showing which holding cost and shortage cost combinations resulted in the same number of backorder weeks or the same fill rate.

The ordering cost changes frequently,also, especially each time civilian pay increases. Because of the way ordering costs and holding costs are both used in determining the Economic Order Quantity a change in ordering costs can be translated to a change in holding costs. Then the graph showing which holding costs and shortage cost combinations have the same level of spending can be used to determine which shortage cost to use to maintain spending within the current year's budget.

EOQ HOLDING COST EVALUATION

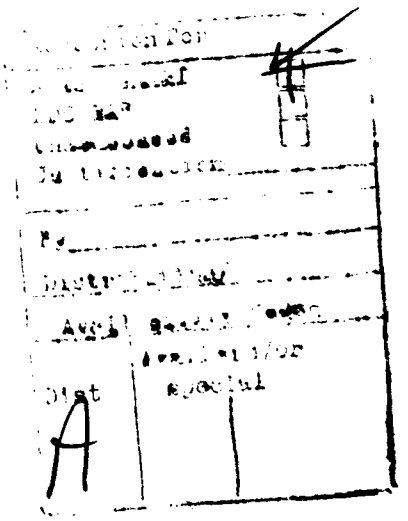


TABLE OF CONTENTS

SUMMARY

The primary purpose of the holding cost study was to build a reference chart of the effect on purchases and support statistics for use when the holding cost changed. The relationship between holding cost and ordering cost in the EOQ formula allows this chart to also be utilized when the ordering cost changes. A secondary result of the study was charts showing the relationship between holding cost, shortage cost and buy dollars or backorders or fillrates.

EOQ holding cost varies from ALC to ALC. Each year these holding costs are updated and can change. As they change questions arise as to what will happen to buy dollars, fillrates, backorders and number of purchases. This study simulated samples of items through a period of time using several holding costs. Comparison of the resultant buy dollars, fillrates, backorders and number of purchases showed the effect of changing the holding cost. The magnitude of the effect varied depending on the initial holding cost. The tables included show this effect of changing the holding cost through a wide range of feasible holding costs.

The simulation results were also used to develop a graph showing which combination of holding costs and shortage costs should result in the same level of spending. This is helpful when funding is already determined but the holding cost must change and the shortage cost that will allow the funding to remain constant must be determined. Similar graphs were developed showing which holding cost and shortage cost combinations resulted in the same number of backorder weeks or the same fillrate.

The ordering cost changes frequently also, especially each time civilian pay increases. Because of the way ordering costs and holding costs are both used in determining the Economic Order Quantity a change in ordering costs can be translated to a change in holding costs. Then the graph showing which holding costs and shortage cost combinations have the same level of spending can be used to determine which shortage cost to use to maintain spending within the current year's budget.

BACKGROUND

Holding costs change because of the annual evaluation of the elements comprising holding costs for each ALC or at the direction of OMB. When this happens the budget may need adjusting and/or the shortage cost may have to be adjusted to maintain a constant level of spending. What these adjustments should be is often decided using intuition or based on an average item for each stock class. Simulation is an alternate tool to make these decisions. However, current simulation models are too computer time and resource consuming to provide timely answers for specific questions as they arise. Thus, there was a need for an easy to use reference based on simulation results that answers a wide range of questions.

METHODOLOGY

INSSIM

Inventory System Simulator, INSSIM is a simulation model for our EOQ systems. It duplicates the supply actions of the D062 system for a 3-4 year period using historical data on selected samples to drive the simulation. Each item starts with the same asset position held on 1 January 1973. The reorder level and economic order quantity are determined periodically based on the previous two years demands. Demands are simulated for the items so that they match the actual demands for each quarter. Purchases are made as the reorder level is reached and they arrive after lead time has passed. As demands occur they are subtracted from the current inventory, if possible, and recorded as a fill. If the current inventory is zero, they are recorded as a backorder. When a purchase arrives, backorders are filled and the remaining stock is added to the current inventory. These backorders and purchases are also recorded. At the end of the simulation these fillrates, backorders, buy dollars and number of purchases are output for analysis along with other result statistics.

These simulations can be repeated using the same sample but with different holding costs and shortage costs. Varying these costs affects the reorder level and order quantity causing different supply actions to occur. Comparing the results of these simulations shows how the holding cost affects the buy dollars, fillrates, and backorders, and purchases for an individual sample.

The history tape provides the demands on a quarterly basis. A random number generator is used to provide the timing of the demands within the quarters. This study used two sets of random numbers to provide the timing of the demands. All samples were run with both demand patterns.

Sampling and Simulation Parameters

Four samples were used for this study. The items in all samples had annual dollar demand between $316 and $10,000,000. The lower limit excluded items having only one buy in the three year simulation and the upper limit excluded bad data points. All samples were run with ten holding costs; .10, .13, .16, .19, .21, .24, .27, .30, .33 and .36. Thus the results can cover the wide range of possible holding costs.

The preliminary sample had 500 items from Oklahoma City and was simulated for four years. Four shortage costs were used; 240, 315, 390 and 465. Each shortage cost was used with each of the ten holding costs for both demand patterns. Thus, eighty simulations were done on this sample.

The other three samples had 1000 items. The first was from Oklahoma City and was simulated for four years. The second was also from Oklahoma City but was simulated for three years. The third sample was from Sacramento and was simulated for three years. Eight shortage costs were used on the 1000 item samples; 200, 260, 320, 380, 440, 500, 560, and 620. Thus each of these samples had 160 simulations.

Computations

The buy dollars, requisition fillrate, unit fillrate, requisition backorder weeks, unit backorder weeks, and number of purchases were recorded for each simulation. The percentage of change in buy dollars between adjacent holding costs was determined for each shortage cost and demand pattern within each sample. That is, the percent of change of buy dollars from sample one, shortage cost 240, first demand pattern, holding cost .10; to buy dollars for sample one, shortage cost 240, first demand pattern and holding

cost .13 was calculated. Fifty-six of these percents of change of buy dollars were calculated between .10 and .13. There were eight from the first sample and sixteen from each of the other three samples. The average of the sample of 56 percents of change in buy dollars between .10 and .13 was divided by 3 to give the percent of change per hundredth of change in holding cost in the range of .10 to .13. This result, 1.24%, is included in Table I. The same procedure was used to find the percents of change in buy dollars across the range of holding costs used in the simulations, .10 to .36.

The percents of change in requisition backorder weeks, unit backorder and number of purchases were also calculated using the method above. The results are also in Table I as are the change in requisition fillrate and unit fillrate. These last two are done almost the same as buy dollars. The difference is that these are actual changes and not percents of changes. It was not necessary to resort to percent of change as the numbers changing are nearly the same for all samples. For instance, the requisition fillrate only varied from .894 to .965. Buy dollars, however, varied from 6 million to over 15 million.

Application When Ordering Cost Changes

The cost to order is currently updated when civilian and military pay is increased. It is increased by the same percentage as the civilian pay increase. If pay increases 5%, the new ordering cost is 1.05 times the old ordering cost.

The change in ordering cost can be translated to a change in holding cost. The economic order quantity is

$$\sqrt{2AC/H}$$

where A is the annual demands measured in dollars, C is the ordering cost and H is the holding cost. When the ordering cost is multiplied by y to reflect the pay increase, the economic order quantity becomes

$$\sqrt{2AyC/H}.$$

If the numerator and denominator of the fraction involved are both divided by y, then the economic order quantity is

$$\sqrt{\frac{2AyC}{H}} = \sqrt{\frac{2AyC/y}{Hy}} = \sqrt{\frac{2AC}{H/y}}.$$

Thus multiplying the ordering cost by y is equivalent to dividing the holding cost by y. The relationship between ordering cost and holding cost allows the use of the effect of changing holding cost, to also determine the effect of changing ordering cost.

Holding Cost - Shortage Cost Relationships

Another aspect of this study was to show the relationships between holding cost and shortage cost. Thus, constant buy dollars, backorders or fillrates can be maintained when the holding cost changes by making the appropriate change in shortage cost.

The approach used for buy dollars was to total the buy dollars for each holding cost - shortage cost combination. Since the 500 item sample had different shortage costs than the 1000 item samples, only the 1000 item samples were used in this portion of the study. All holding cost shortage cost combinations were run with two demand patterns for each of the three different samples. Therefore, six simulation results were totaled to get the buy dollars for each holding cost shortage cost combination. This information was summarized in a chart with each line showing the buy dollars for each shortage cost, given a constant holding cost. This information was then rearranged using interpolation to which shortage costs and holding costs would have provided certain levels of spending.

The same process was used on unit backorder weeks. Requisition fillrate was also done but here

the average fillrate for the six samples was used. Both requisition unit fillrates and backorder weeks were not used to save time.

FINDINGS

There are two types of results available from this study. The first set of results are the effect on buy dollars, purchases, fillrates and backorders when the holding costs are changed. The second set shows the relationship between shortage cost and holding cost when maintaining constant buy dollars, backorders or fillrates. Included along with the numerical results are explanations of when and how to use these numbers as well as examples to illustrate the techniques involved.

Effect of Changing Holding Costs

The holding costs were changed to several values thru the range of .10 to .36. The interval between the holding costs costs was generally .03 but one interval was only .02. The small interval,.19 to .21, was included because it was of special interest to LORF. Rather than give the effect of changing the holding cost for the entire interval, the results were changed to an average change of one one-hundredth for each interval. This resulted in figures that were easier to use and analyze. Table 1 shows the effect

of increasing the holding cost by one one-hundredth through the range of .10 to .36. Results are given for buy dollars, backorder weeks, fillrates, and number of purchases. If a change is more than one one-hundredth, the results for each portion of the change can be added to find the result of the total change. The final results should be rounded to the nearest tenth of a percent for buy dollars, to the nearest percent for backorder weeks and purchases and to the nearest thousandth for fillrate. The results in Table 1 can also be used to determine the expected result of changing the ordering cost. A full explanation of how and why this can be done was given in the Methodology section. Example 3 illustrates its use.

Table 2 through 7 are graphs of the same information found in Table 1. However, here the effect of the different holding costs is more readily apparent. It is easier to see the trends. Table 2, showing the percent of buy dollar decrease across the range of holding costs, demonstrates that the magnitude of the buy dollar decrease steadily decreases as the holding cost increases. This also occurred for the increase in the number of purchases but not for either of the backorders or fillrates.

There is some loss of accuracy in using average changes within a holding cost interval. Using the average change for the center of each holding cost interval and interpolating to determine the other changes within the interval improved the accruacy of the buy dollar decrease. The results are in Table 8. The same method is possible on the number of purchases but it was not done as greater accuracy is not necessary. The lack of a definite pattern the backorder and fillrate changes prevents the use of interpolation as a method for improving accuracy.

Example 1: What is the effect on buy dollars of changing the holding cost from .18 to .21?

Increases of holding cost	=	decrease in buy dollars	
		TABLE 1	TABLE 8
.18 to .19	=	.63%	.60
.19 to .20	=	.56%	.57
.20 to .21	=	.56%	.54
.18 to .21	=	1.75%	1.71%

Rounding off to the nearest tenth, an increase in the holding cost from .18 to .21 results in a decrease of 1.8% in buy dollars using Table 1. However, using the more accurate Table 8, there is only a 1.7% decrease in buy dollars.

Example 2: What is the effect on unit backorder weeks of decreasing the holding cost from .22 to .205?

Decrease in holding cost	=	decrease in unit backorder weeks
.22 to .21	=	1.46%
.21 to .205	=	1/2 (1.41)% or .72%
.22 to .205	=	2.18%

Rounding to the nearest percent, decreasing the holding cost from .22 to .205 decreases the unit backorder weeks by 2%.

Example 3: There is a pay raise of 5.5%. The holding cost is currently .22. What will be the effect on buy dollars when the new ordering cost is used to determine the economic order quantity?

The new ordering cost can be found by multiplying the old ordering cost by 1.055. It will have the same effect on buy dollars as if the holding cost had been divided by 1.055. Therefore, Table 8 can be used by finding the effect of changing the holding cost from .22 to .22/1.055 or .2085.

Decrease in holding cost	=	Increase in buy dollars
.22 to .21	=	.49%
.21 to .2085	=	.15(.54) or .08%
.22 to .2085	=	.57%

Rounding off to the nearest tenth of a percent, a decrease in the holding cost from .22 to .2085 or an increase of 5.5% in ordering cost while the holding is .22 will increase buy dollars by 0.6%.

Constant Buy Dollars

Tables 9 and 10 show the relationship between buy dollars, holding cost and shortage cost. Table 9 shows the spending on all the simulations of 1000 items. Each line shows the spending for the various shortage costs and one holding cost. This information was transformed to build Table 10. Here lines were drawn between the holding costs and shortage costs that produce the same level of spending. Table 10 is the easiest to use. First, mark the point where the current holding and shortage costs meet. Then draw a line through that point parallel to the nearest constant spending line. This new line will cross the proposed holding cost at the shortage cost that will keep spending constant.

Example 4: The current holding cost is .13 and the current shortage cost is 350. The holding cost is changing to .15. What shortage cost should be used to maintain current spending? Holding cost .13 meets shortage cost 350 at a constant spending line labelled 62 million. This line crosses all the

holding cost - shortage cost combinations that maintain the present spending level. It crosses holding cost .15 at shortage cost 425. Thus, if the holding cost is at .13, the shortage cost at 350 and the holding cost is being changed to .15, a change in shortage cost to 425 will maintain the same level of spending.

Constant Requisition Fillrate

Table 11 shows the average requisition fillrate for the shortage costs combined with each holding cost. Each line represents a different holding cost. As with buy dollars, the information in Table 11 was used to build Table 12. The holding cost and shortage cost combinations that produced the same requisition fillrates are connected in Table 12. The irregularity of the holding cost lines in Table 11 was magnified in converting from Table 11 to Table 12. Therefore Table 11 is more reliable and should be used rather than Table 12. Again, start with current holding cost and shortage cost. Then follow the line of constant requisition fillrate, which is horizontal to the new holding cost. This gives the new shortage cost.

Example 5: Currently the holding cost is .13 and the shortage cost is 350. What shortage cost should be used to maintain the requisition fillrate

if the holding cost is moved to .15? On Table 11 holding cost .13 crosses shortage cost 350 at an average fillrate of .942. Following the line across two-thirds of the way to .16 puts the shortage cost at 410.

Constant Unit Backorder Weeks

Tables 13 and 14 show the relationship between unit backorder weeks, holding cost and shortage cost. Table 13 shows the backorders for each holding cost simulated. Table 14 shows the holding cost and shortage cost combinations that produced the same backorder level. As with fillrates Table 13 translated poorly to make Table 14 difficult to use. Therefore, Table 13 should be used to determine what shortage cost to use to maintain a constant backorder level if the holding cost is forced to change. Start at the junction of the current holding cost and shortage cost. Follow the horizontal line of constant unit backorder weeks to the new holding cost. This point is also at the current unit backorder weeks.

Example 6: As in examples 4 and 5 the current holding cost is .13 and the shortage cost is 350. What shortage cost should be used to maintain constant unit backorder weeks if the holding cost is changed to .15? On Table 13 shortage cost 350 crosses holding

cost .13 at unit backorder weeks of 1,195. Two thirds of the way across to holding cost .16 is the shortage cost of 385.

Further Analysis of Examples 4, 5 and 6

A comparison of examples 4, 5 and 6 reveals some interesting results. All three problems started with a holding cost of .13 and shortage cost of 350 and the holding cost was to change to .15. Keeping buy dollars constant could be done with a shortage cost of 425. Keeping requisition fillrate constant could be done with a shortage cost of 410. However, keeping unit backorder weeks constant could be done with a shortage cost of 385. Thus, using a shortage cost of 425 would keep the buy dollars the same but fillrates would be higher and backorder weeks would be lower.

CONCLUSIONS AND RECOMMENDATIONS

In addition to the numerical results, efforts were made to determine the adequacy of the study results, provide guidelines for further studies using INSSIM and indicate further areas for improving the results from this study. Pertinent findings in these areas are included here.

Recommendations were made for rounding the results when determining the effect of changing the holding or shortage cost. They were based on confidence intervals built on selected parts of the results. For instance, there were 56 separate simulation results for the average decrease in buy dollars for increasing the holding cost by .01 while in the range from .21 to .24. These results had a mean of .45% and a sample variance of .12%. Thus, using the fact that every random sample of at least 30 has a normal distribution, over 95% of the time any other sample of at least 30 will have a mean between the mean of the first sample, plus or minus two times its variance. The EOQ system meets the criteria as it is equivalent to using over

500 samples of 1000 items each. Therefore, there is a 95% chance that changing the holding cost by .01 somewhere between .21 and .25, the EOQ buy dollars will decrease somewhere between .31% and .69%. Thus, the EOQ system change should be within 3 tenths of a percent of the study results for the .21 to .24 interval. Confidence intervals were not built for the buy dollar change for any of the other holding cost intervals but they should be similar. Rounding the final results to at least the nearest tenth of a percent is necessary to eliminate those digits that indicate accuracy that definitely doesn't exist.

Confidence intervals were built for the change in unit backorder weeks, requisition fillrates, and number of purchases for a .21 to .24 holding cost change only. These confidence intervals were used to make the recommendations for rounding of the results. The only other consideration was to eliminate those digits that would not be of interest to LORF. The difference between a change in fillrate of .0012 or .0014 is immaterial.

Analysis of variance, a statistical method used to determine what caused the variation within a group of results, was done for the most important effect, the change in buy dollars. The results however have wider ranging implications. Only the 1000 items

sample results were used because the analysis was more powerful when all samples used the same shortage cost.

From the analysis of variance in Table 15 it is concluded that there were several causes of the variation between the individual buy dollar change results. There is less than a 1% chance that these conclusions are wrong. The causes of the variation and the percent of the variation they caused are:

1.	Holding Cost	85%
2.	Shortage Cost	4%
3.	Sample	2%
4.	Interaction between above three	4%

The variation caused by the different holding costs was as expected. However, the other causes of significant differences lead to further analysis and the following observations.

The variation between samples was analyzed further to find the samples' results that were different from the others. The use of contrasts allow this to be done. The contrasts used are in Table 16. The first looked at the differences between ALCs - the Oklahoma City 3 year simulation sample versus the Sacramento 3 year simulation sample. The second

compared the Oklahoma City 3 year simulation and the Sacramento 3 year simulation with the 4 year Oklahoma City simulation. Both of these contrasts showed significant differences with less than 1% chance for error in making those conclusions. However, there was approximately five times as much variation explained by the second contrast than in the first. If there had been two three year simulation samples from the same ALC and their results were not significantly different, the conclusion could be made that the variations in the first contrast were due to ALC differences. However, given the current study it is not possible to conclude whether the differences were due to ALCs or only due to having different items in the sample.

The large amount of difference between the 3 year and 4 year simulation highlights some problems with INSSIM. The number of years possible for simulation is limited. In a longer simulation, one year of simulation would not make as much difference. There are unusually large purchases the first quarter of any simulation using INSSIM. This could cause some of the differences in the result for a 3 or 4 year simulation. It would be better for the simulation to reach a steady state before performance statistics

were kept. Also it is desirable to be able to change the simulation parameters, i.e. holding or shortage costs, after steady state is reached.

The variation between the results when using the various feasible shortage costs validates the use of several shortage costs in this general purpose study. But, this variation, the interaction between holding cost, shortage cost and sample, as well as the use of holding cost intervals larger than .01 indicate the need for very specific simulations with more samples from all the ALCs if more definitive results are desired.

For many purposes the results of this study are as accurate as needed. When holding or ordering cost change, these study results can be used to determine what effect the change will have on purchases and support or how to adjust the shortage cost to maintain constant buy dollars or support.

Change per Increase of One Hundredth of Holding Cost

	Holding Cost Range								
	.10-.13	.13-.16	.16-.19	.19-.21	.21-.24	.24-.27	.27-.30	.30-.33	.33-.36
% Decrease in Buy Dollars	1.24%	.83%	.63%	.56%	.45%	.39%	.30%	.24%	.20%
Decrease in Requisition Fillrate	.00116	.00106	.00094	.00080	.00085	.00094	.00063	.00063	.00057
Decrease in Unit Fillrate	.00005	.00081	.00165	.00181	.00114	.00123	.00049	.00071	.00083
% Increase in Requisition Backorder Weeks	2.42%	1.76%	1.46%	1.09%	1.27%	1.18%	.90%	.74%	.74%
% Increase in Unit Backorder Weeks	.93%	1.32%	1.83%	1.41%	1.46%	1.40%	.84%	.85%	.89%
% Increase in Number of Purchases	1.52%	1.18%	1.03%	.75%	.71%	.59%	.57%	.49%	.43%

Table 1

Buy Dollar % Decrease per Increase of One Hundredth of Holding Cost

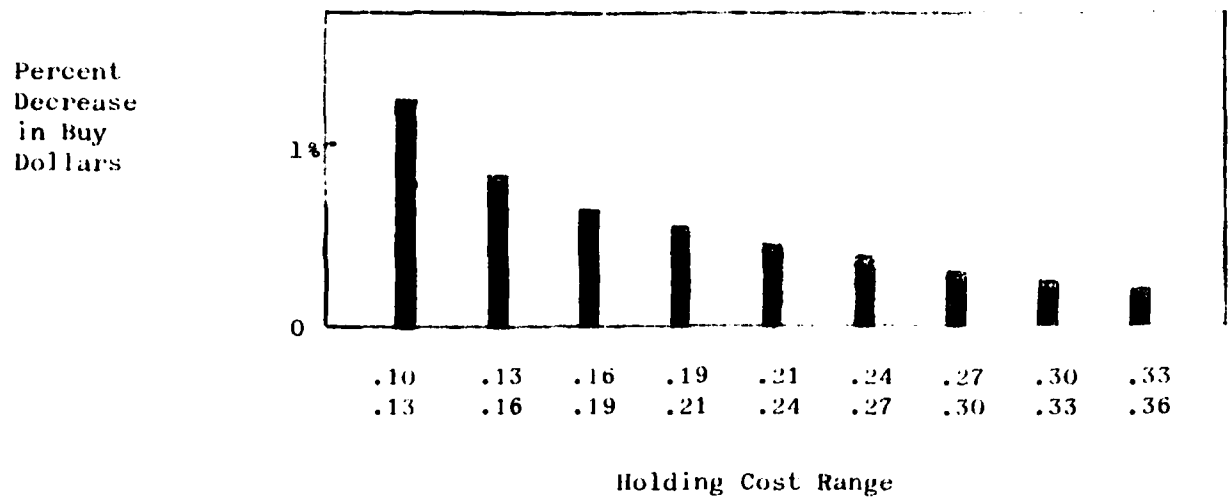


Table 2

Requisition Fillrate Decrease per Increase of One Hundredth of Holding Cost

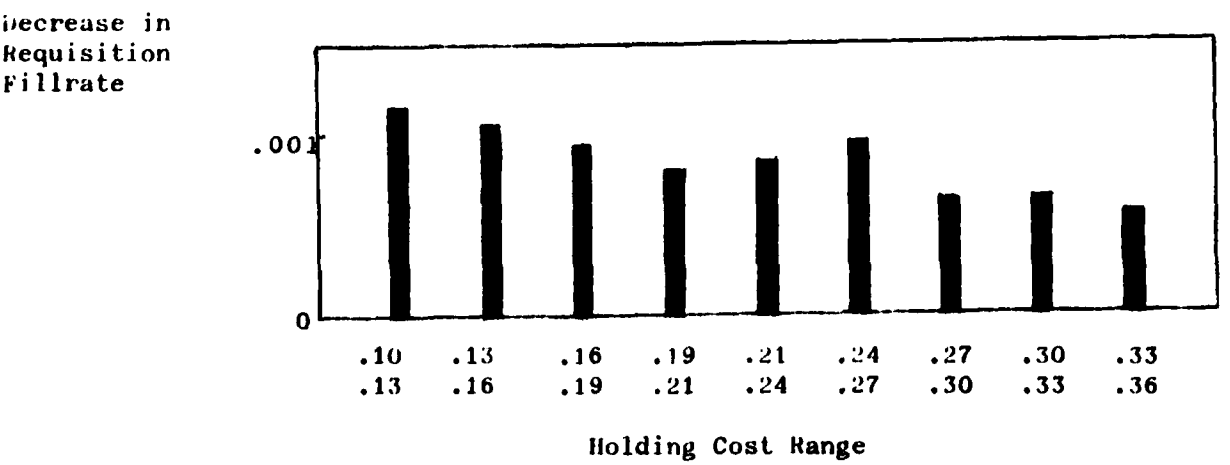


Table 3

Unit Fillrate Decrease per Increase of One Hundredth of Holding Cost

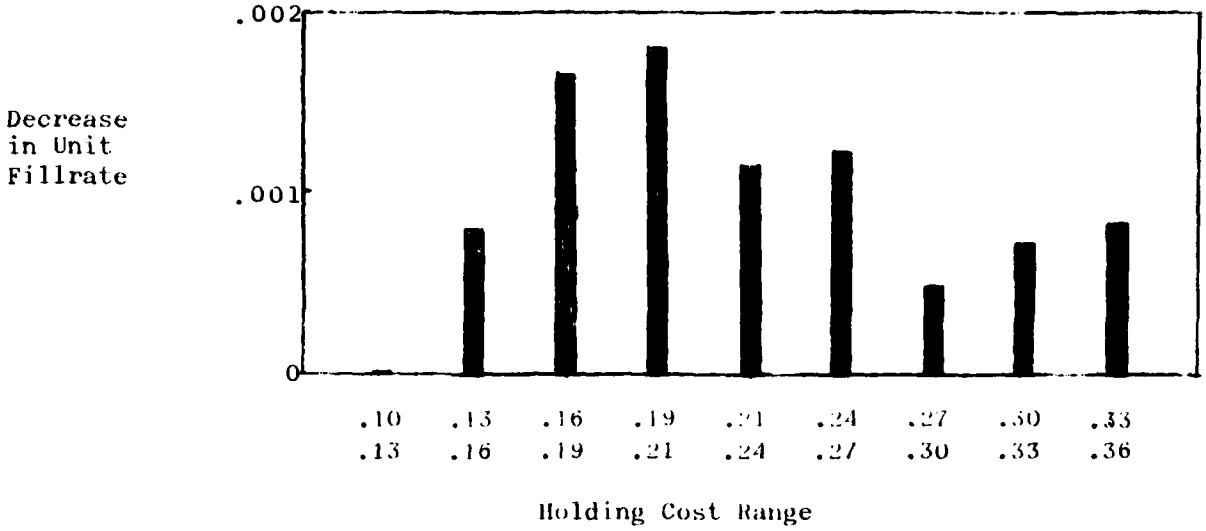


Table 4

% Increase in Requisition Backorder Weeks per Increase of One Hundredth of Holding Cost

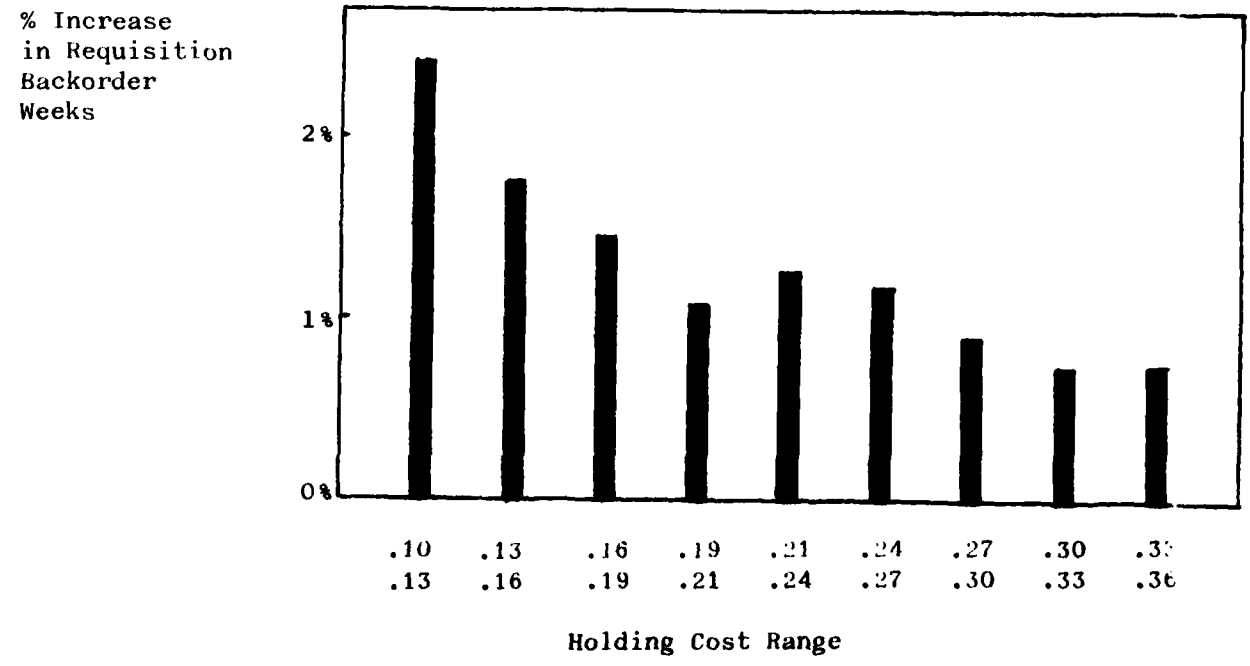


Table 5

% Increase in Unit Backorder Weeks per One Hundredth Increase in Holding Cost

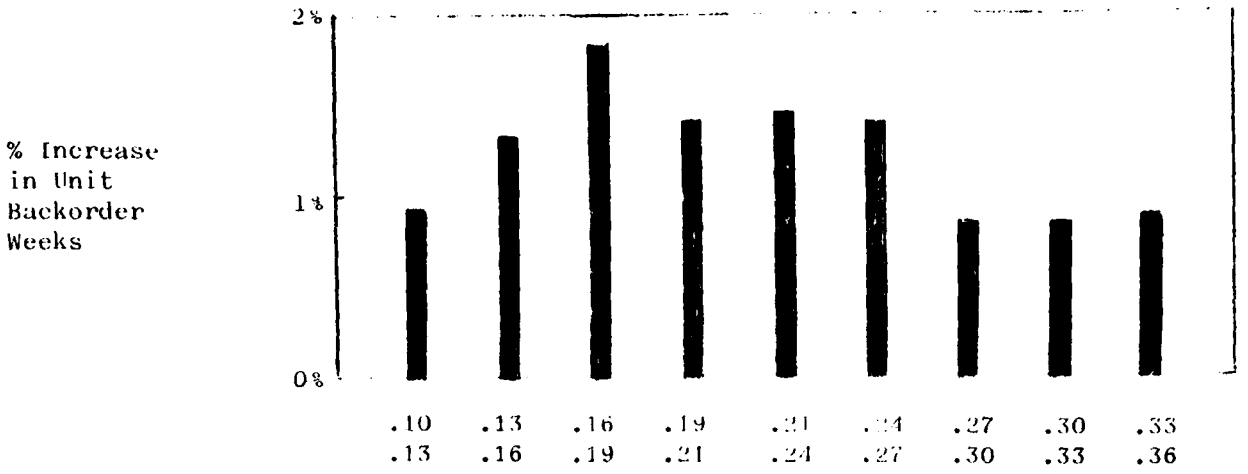


Table 6

Number of Purchases % Increase of One Hundredth of Holding Cost

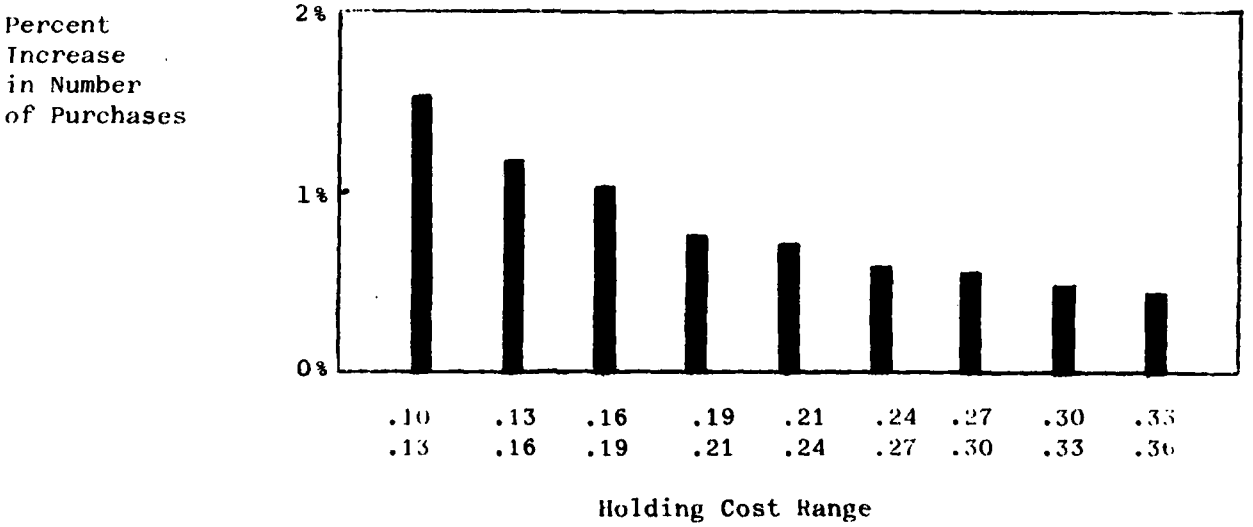


Table 7

% Buy Dollar Increase for a Change to the Next Highest Holding Cost

Initial Holding Cost	Average Increase for Interval	Interpolated Increase
.10		1.38%
.11	1.24%	
.12		1.10%
.13		.97%
.14	.83%	
.15		.76%
.16		.70%
.17	.63%	
.18		.60%
.19		.57%
.195	.56%	
.20		.54%
.21		.49%
.22	.45%	
.23		.43%
.24		.41%
.25	.39%	
.26		.36%
.27		.33%
.28	.30%	
.29		.28%
.30		.26%
.31	.24%	
.32		.27%
.33		.23%
.34	.20%	
.35		.17%

Table 8

Buy Dollars and Shortage Cost

for Several Holding Costs

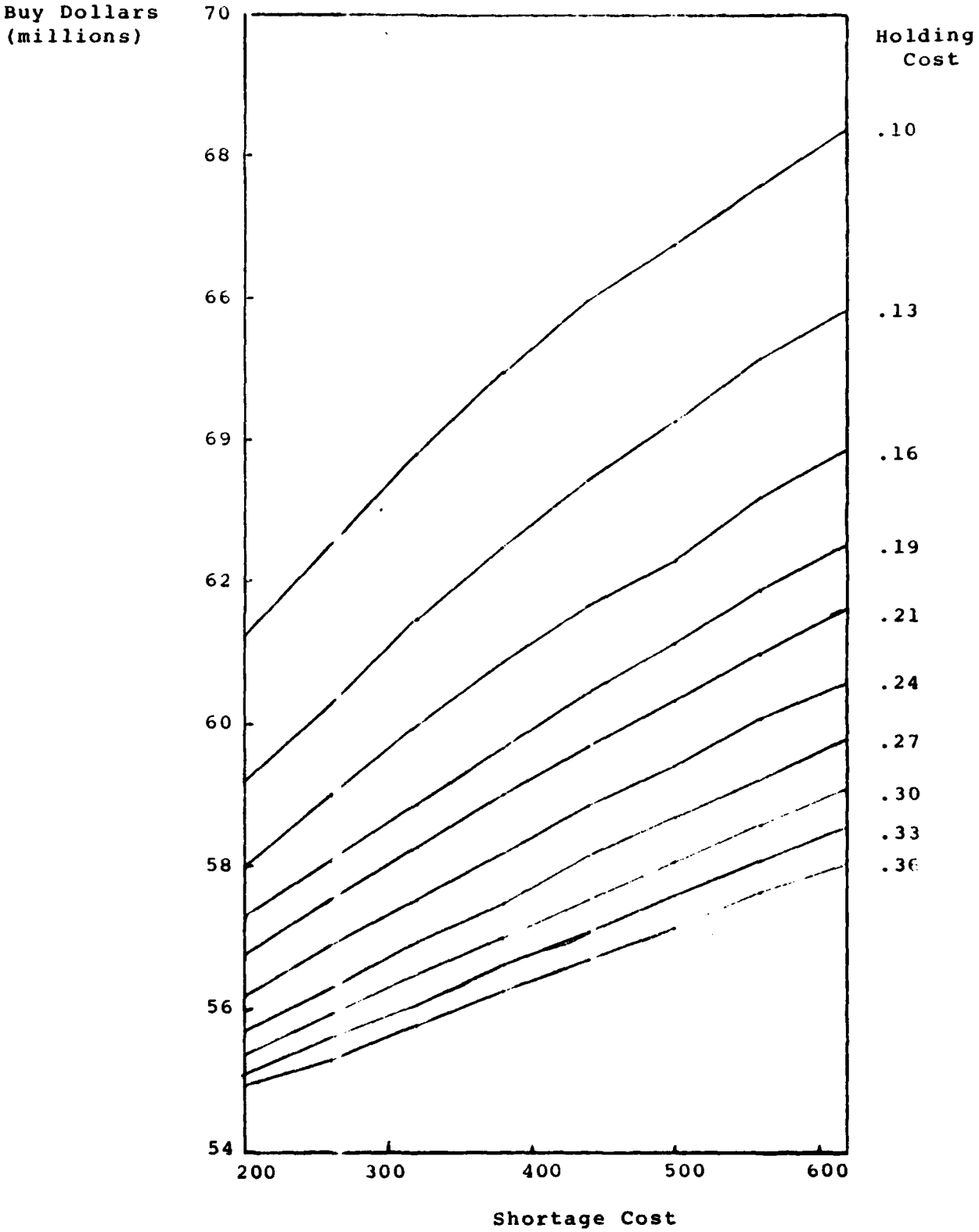


Table 9

CONSTANT BUY DOLLARS

FOR HOLDING COST AND SHORTAGE COST COMBINATIONS

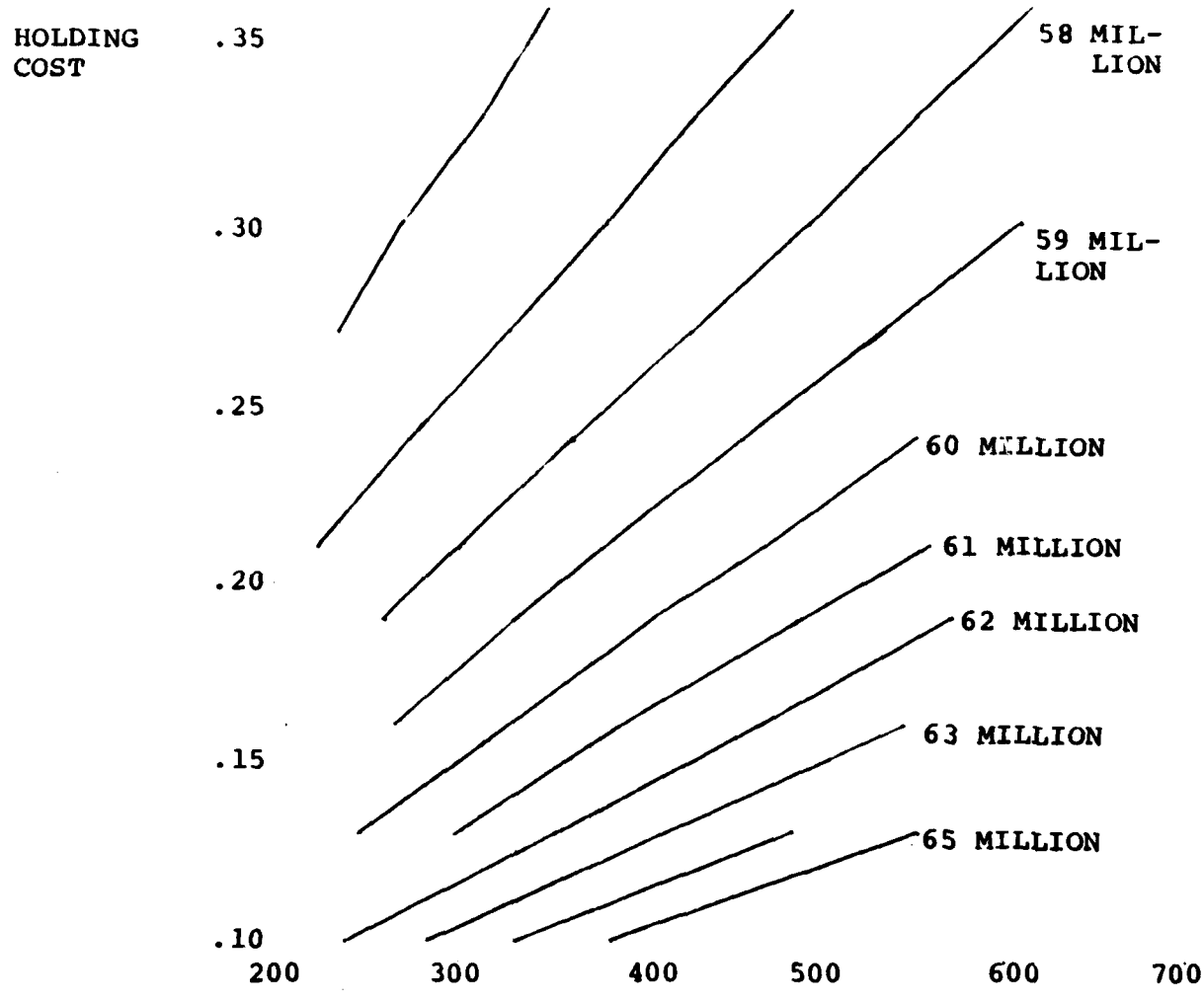


TABLE 10

REQUISITION FILLRATE AND SHORTAGE COST
FOR SEVERAL HOLDING COSTS

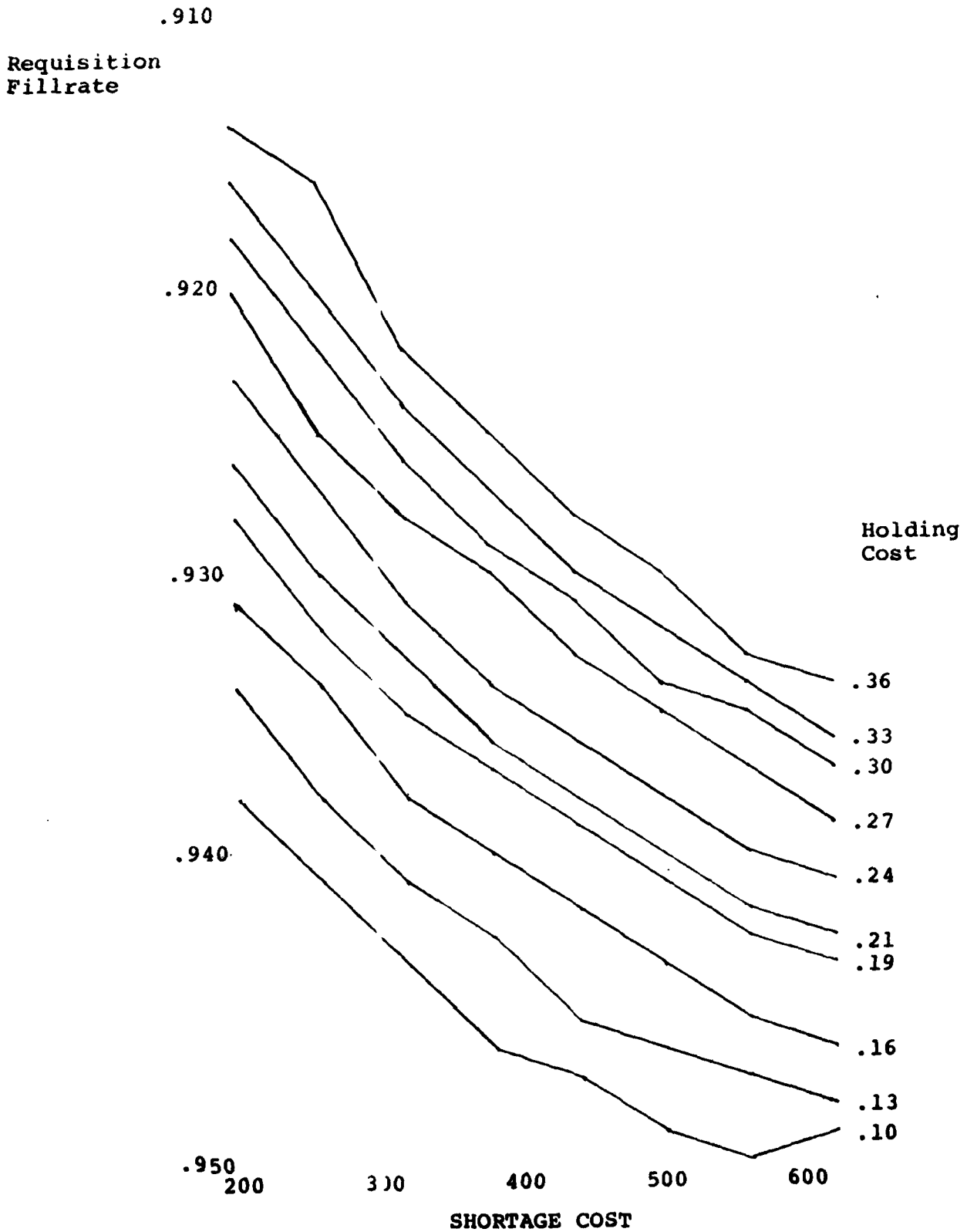


TABLE 11

CONSTANT REQUISITION FILLRATE

FOR HOLDING COST AND SHORTAGE COST COMBINATIONS

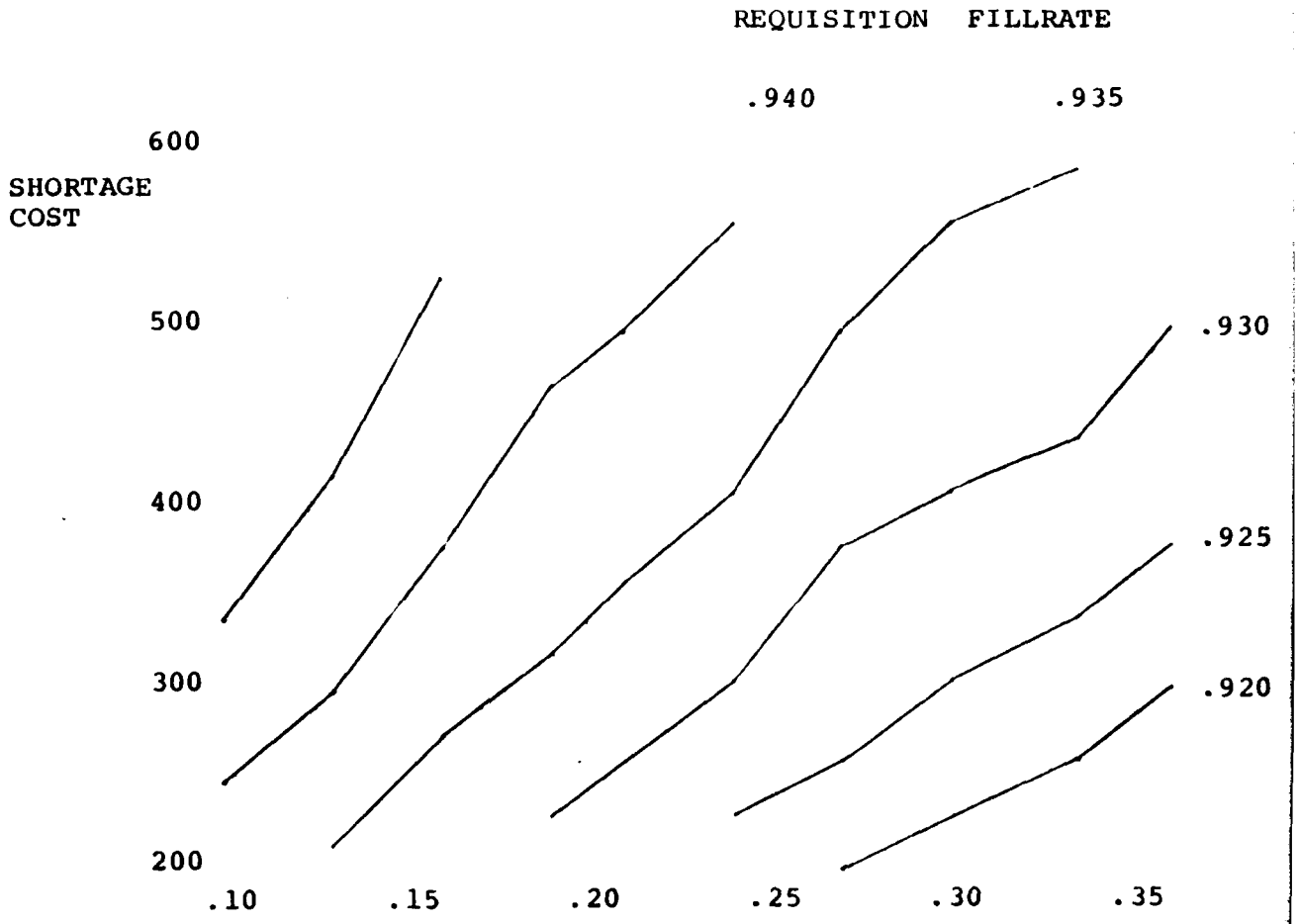


TABLE 12

UNIT BACKORDER WEEKS AND SHORTAGE COST

FOR SEVERAL HOLDING COSTS

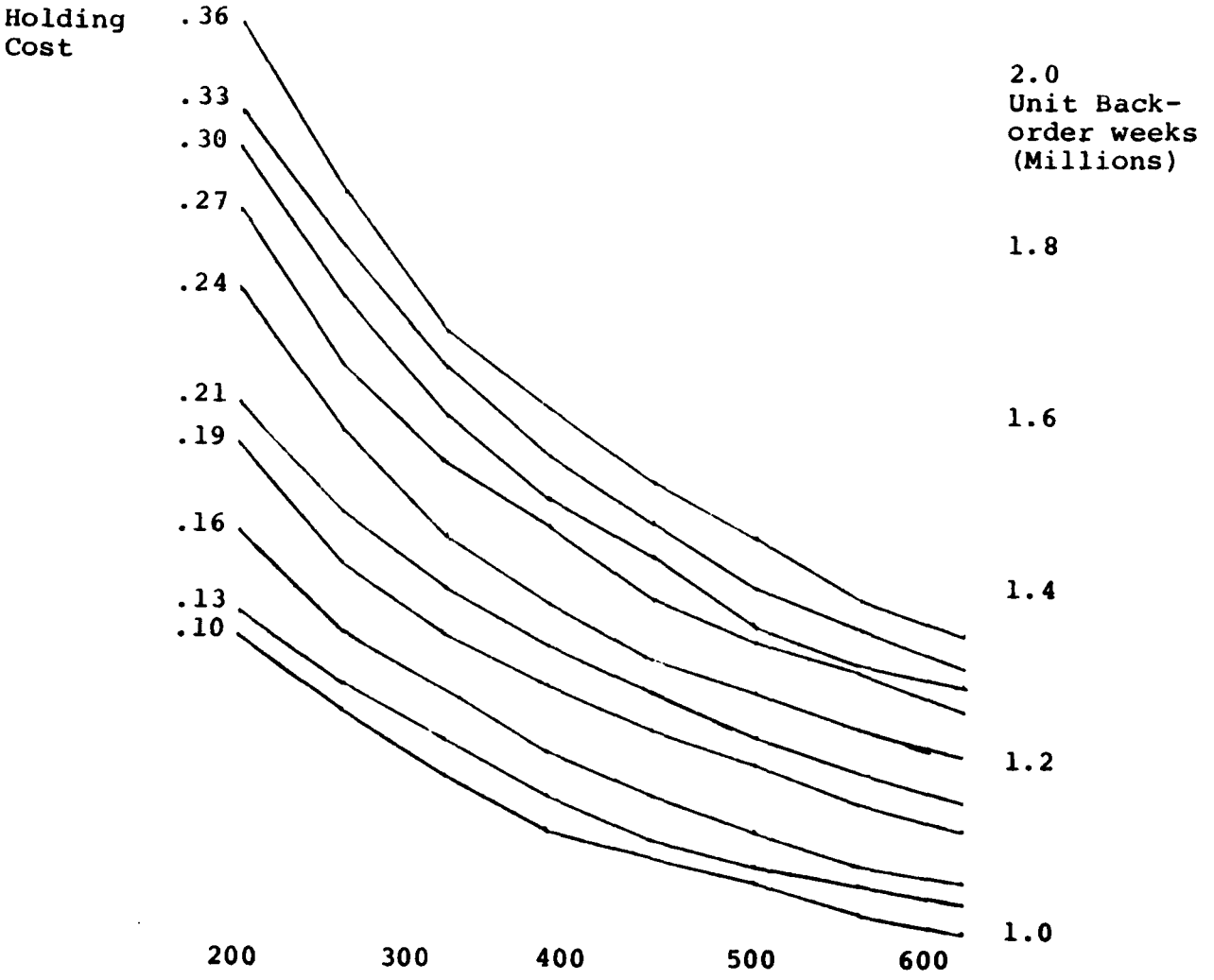


TABLE 13

CONSTANT UNIT BACKORDER WEEKS
FOR HOLDING COST AND SHORTAGE COST COMBINATIONS

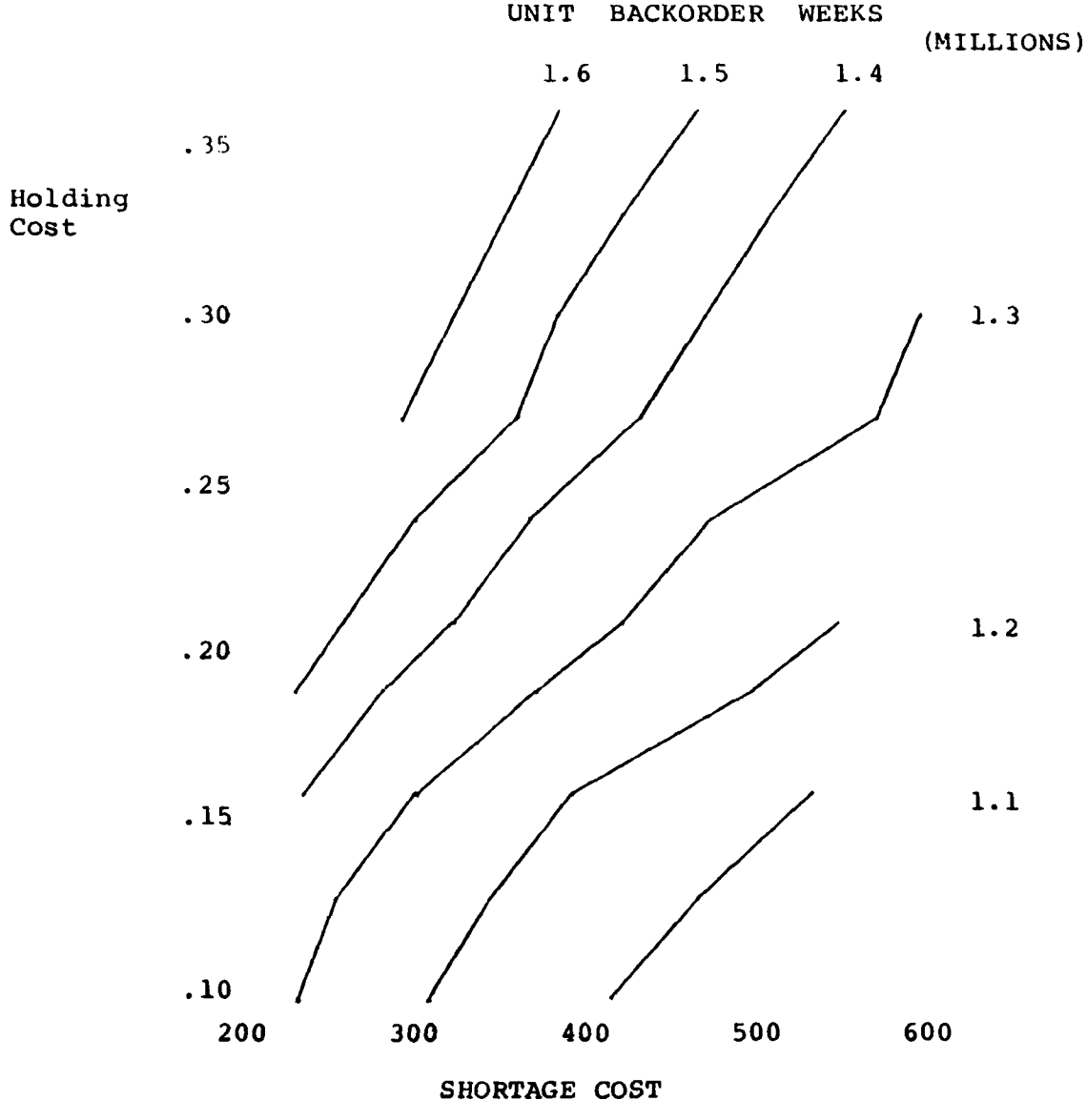


TABLE 14

ANALYSIS OF VARIANCE

Percent of Increase in Buy Dollars

SOURCE OF VARIATION	DF	SS	MS	F_{Cal}	F_{Test}
Main Effects					
Sample	2	.840	.420	35.59*	$F_{2,200,.01} = 4.71$
Shortage	7	1.980	.283	23.98*	$F_{7,200,.01} = 2.73$
Holding Cost	8	44.811	5.601	474.66*	$F_{8,200,.01} = 2.60$
INTERACTION					
Sample/Shortage	14	.097	.0069	.59	$F_{15,200,.01} = 2.13$
Sample/Holding Cost	16	.049	.0031	.56	$F_{15,200,.01} = 2.13$
Shortage/Holding Cost	56	.343	.0061	.52	$F_{50,200,.01} = 1.63$
Shortage/Holding Cost/Sample	112	2.133	.0190	1.61*	$F_{100,200,.01} = 1.48$
RESIDUAL	216	2.555	.0118		
TOTAL	431	52.807			

* significant differences at the 1% level

TABLE 15

CONTRAST FOR SAMPLES

Percent of Increase in Buy Dollars

	OKLAHOMA CITY 3-YEAR SIMULATION	OKLAHOMA CITY 4-YEAR SIMULATION	SACRAMENTO 3-YEAR SIMULATION
C_1 =	- 1	0	1
C_2 =	1	- 2	1

CONTRAST COEFFICIENTS

	SS	F_{Cal}	F_{Test} =	$F_{1,200,.01}$
C_1 =	.1454	12.32*	6.76	
C_2 =	.6919	58.64*	6.76	

* significant differences at the 1% level

TABLE 16